



## Advanced Technology for Cyclones Storm Damage Risk Reduction Systems and Flood Protection Levees

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### Overview:

In August 2005, Hurricane Katrina became one of the most expensive natural disasters in the U.S. history. Continuous waves pounded the crest of hurricane protection levees, causing thousands of gallons of water to cascade down the faces of earthen slopes. The storm surge overtopping resulted in scouring of levee land sides, and in some cases led to overturned flood walls and breaches. Hundreds lost their lives, and thousands more experienced catastrophic destruction. Lack of protection of levee land sides from erosion was cited as a major cause of catastrophic destruction and spurred new requirements for resiliency of levee infrastructure across the United States. In response to the impacts of Hurricanes Katrina and Rita in 2005, the U.S. Army Corps of Engineers (USACE) embarked on one of the largest and most comprehensive public works projects in American history to provide a 100-year level of risk reduction, meaning that infrastructure would be established to defend against a storm surge that has a 1% change of occurring in any given year.

### Objective:

The USACE —New Orleans District initiated the \$14.5 billion Hurricane and Storm Damage Risk Reduction System (HSDRRS) program in 2006, strengthening levees, floodwalls, gated structures and pump stations for a more than 200km perimeter. One of the most critical measures of the HSDRRS was protection of refurbished earthen levees against the erosion-causing hydraulic forces of storm surge overtopping. This paper will introduce the HSDRRS program and its solution along with considerations about how to use this program in other areas and present test results as well as international and local case studies.

### Method:

Standards were developed to qualify methods of armouring for erosion protection, utilising turf reinforcement mats installed on levee land sides. Field testing of High Performance Turf Reinforcement Mat (HPTRM) materials began in 2011, with stringent requirements for withstanding installation and maintenance loads. Vegetation establishment through HPTRMs, as well as ease of installation, was observed over a two-year pilot program on HSDRRS levees. The final qualification of HPTRMs for armouring of HSDRRS levees was performed in 2012 at Colorado State University where vegetated HPTRMs were tested using a full-scale Wave Overtopping Simulator, replicating hurricane storm surge waves over many hours. Additionally, the Louisiana State University (LSU) Agricultural Centre performed multiple non-hydraulic tests on this anchored armouring system to evaluate the ability of vegetation to establish within the HPTRM and to test how the material would hold-up against heavy mowing equipment.

#### Results:

Testing showed that using an armouring system consisting of high performance turf reinforcement mat (HPTRM) with Engineered Earth Anchors performed substantially better than all other systems in protecting against erosion. This armouring system has been Recognised by the Environmental Protection Agency (EPA) as well as the Federal Highway Administration (FHWA) as a Best Management Practice (BMP) to improve water quality. Today, this system is still holding its ground, preventing erosion and maintaining its integrity, despite significant rainfalls and storms since 2012, with more than 2.5 million square metres planned to be installed in the near future.

#### Conclusion:

Anchored armouring system can be installed on levees for a fraction of the time and cost. The result is proven performance for erosion protection, with all of the environmentally friendly and aesthetic benefits of fully established vegetation. This system provides a truly sustainable solution for long-term, fiscally responsible protection of global levee infrastructure. Just as it performed behind the Penn Levee in Louisiana after being overtopped during category 4 Hurricane Ike in 2008, the anchored armouring system has provided the USACE with a dependable solution for protecting lives and property in areas vulnerable to cyclones and severe floods. Recently, full scale installation of this system was begun on over 100km of earthen levee in the U.S., after a further rigorous testing program to verify that the system exceeds USACE design standards. This anchored armouring system has been approved and installed successfully around the world and in Australia.